Master 2

INTERNSHIP PROPOSAL

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Internship/PhD location: Bordeaux (France)
Internship Funding: YES

Renormalization group flows for tensor models

Matrix models (see the review articles [1] or B. Eynard's book [2]) are QFT models where the fields are not scalars or vectors, but N-dimensional matrices. Matrices models have been successfully related to 2D quantum gravity and to various domains of physics, such as string theory (since they are related to 0-dimensional string theory, a pure theory of surfaces with no coupling to matter on the string worldsheet).

Tensor models (see the books [3] and [4] or I. Klebanov's TASI lectures [5]) were introduced as a natural QFT generalization of matrix models in dimension 3 or higher, in order to replicate their various successes.

Initially independently of the study of tensor models, a model of N fermions in 0+1 dimensions was proposed by Sachdev and Ye [6] and it received considerable attention in both condensed matter and high energy physics. In the context of condensed matter physics, this model has been analyzed in various papers, such as the paper of Parcollet and Georges [7], which have computed the 2-point function of this model in the large N limit. A variant of this model was then proposed by Kitaev as a toy model of holography [8]. Since then, this Sachdev-Ye-Kitaev (SYK) model has attracted a huge amount of interest within the high energy physics community. Thus, Maldacena and Stanford studied in detail the 2- and 4-point functions of the model [9], Polchinski and Rosenhaus solved the Schwinger-Dyson equation and computed the spectrum of two-particle states [10] and so on.

Shortly after, Witten proposed a modification of the SYK model, using tensorial fields, and thus obtaining a more conventional large N limit [11]. This comes from the fact that both the SYK model and tensor models have the same structure of the Dyson-Schwinger equation!

A program of the study of the renormalization group flow of SYK-like tensor models have been recently initiated by various research groups. Thus, in [12], the spectrum of the large N quantum field theory of a quartic bosonic rank-3 tensor model was investigated, and Wilson-Fisher-like fixed points have been found. Shortly after, D. Benedetti et. al. studied in [13] the renormalization group flow of a quartic tensor model with a modified propagator, using a Wilsonian approach valid in any dimension. In [14], a renormalization group flow analysis for a tensor model with order 6 interaction (a so-called prismatic interaction) has been done.

The internship proposes to continue this renormalization group study program of tensor models. More precisely, our objective for the internship is to study the beta-function of an order 6 tensor model similar to the one proposed by S. Giombi *et. al.* in [14]. However, we propose to modify the propagator of the model using the so-called short and long-range propagators, and to use an Wilsonian approach such as the one of proposed by D. Benedetti et. al. In [13]. At the end of the internship, it will be highly interesting to compare the fixed points obtained by our analysis with the fixed points of the original model of [14].

Another research direction of the internship is related to Jackiw–Teitelboim (JT) model, which is a model of 2D gravity that has attracted a great deal of attention in recent years. In particular, a connection with random matrices has been established in [15] by D. Stanford and E. Witten. Recently, A. Castro, which is currently a post-doc in A. Tanasa's group in Bordeaux, investigated in [16] a critical behavior of JT gravity. Her approach used techniques inspired from random maps (known to be Feynman graphs of the matrix models mentioned above). During the internship, a study of some sub-critical regimes within the lines of [16] can be initiated.

The internship will be supervised by Adrian Tanasa (Bordeaux) and Thomas Krajewski (Marseille), but Thomas Muller (PhD student in A. Tanasa's group) and A. Castro (post-doc in A. Tanasa's group) will also participate to the supervision process.

Other close collaborators of the group of A. Tanasa in Bordeaux are D. Benedetti (CPHT Ecole Polytechnique) and the members of the mathematical physics group of R. Gurau (Univ. Heidelberg).

The internship is suited for a highly motivated Masters student with good background in mathematical and theoretical physics. The internship may be followed by a PhD proposal in the same area, under the supervision of Adrian Tanasa (Bordeaux) and Thomas Krajewski (Marseille).

References:

[1] Ph. Di Francesco et. al., Phys. Rept. (1995), hep-th/9306153, V. Kazakov, Proc. Cargèse workshop (1990), F. David, Lectures Les Houches Summer School, Ph. Di Francesco, "2D quantum gravity, matrix models and combinatorics", arXiv:0406013 [math-ph].
[2] B. Eynard "Counting Surfaces", Birkhauser (2016).
[3] R. Gurau, "Random Tensors", Oxford Univ. Press (2016).
[4] A. Tanasa, "Combinatorial Physics", Oxford Univ. Press (2021).
[5] I. Klebanov, F. Popov and G. Tarnopolsky, TASI Lectures on Large N Tensor Models, arXiv:1808.09434[hep-th].
[6] Sachdev and Ye, cond-mat/9212030, Phys. Rev. Lett. 70 (1993) 3339.
[7] Parcollet and Georges, cond-mat/9806119, Phys. Rev. B 59 (1999), 5341-5360.
[8] Kitaev, http://online.kitp.ucsb.edu/online/entangled15/kitaev/ (talk at KITP).
[9] Maldacena and Stanford, arXiv:1604.07818[hep-th], Phys. Rev. D 94 (2016) 106002.
[10] Polchinksi and Rosenhaus, arXiv:1601.06768[hep-th], JHEP 1604 (2016) 001.
[11] Witten, J. Phys. A arXiv:1610.09758[hep-th].
[12] Simone Giombi, Igor R. Klebanov, and Grigory Tarnopolsky, Phys. Rev. D **96**, 106014
[13] D. Benedetti, R. Gurau and S. Harribey, JHEP 06 (2019) 053
[14] [7] S. Giombi, I. Klebanov, F. Popov, S. Prakash and G. Tarnopolsky, ``Prismatic Large N Models for Bosonic Tensors," Phys. Rev. D 98, no.10, 105005 (2018), [arXiv:1808.04344 [hep-th]].
[15] D. Stanford and E. Witten, arXiv: 1907.03363[hep-th].
[16] A. Castro, JHEP 08 (2023) 036.